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INVENTORY OF FOREST AND RANGELAND AND DETECTION OF FOREST STRESS

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TECHNICAL REPORT STANDARD TITLE PAGE

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15. Supplementary Notes			
16. Abstract At the Atlanta site (226B) we found that bulk color composites for October 15, 1972, and April 13, 1973, can be interpreted together to disclose the location of the perennial Kudzu vine (<u>Pueraria lobata</u>). Land managers concerned with Kudzu eradication could use ERTS to inventory locations over 200 meters (660 feet) square. Microdensitometer data collected on ERTS bulk photographic products for the Manitou test site (226C) have shown that the 15-step gray-scale tablets are not of systematic equal values corresponding to $1/14$ the maximum radiant energy incident on the MSS sensor. The gray-scale values present a third-order polynomial function rather than a direct linear relationship. Although data collected on step tablets for precision photographic products appear more discrete, the density variation within blocks is almost as great as variations between blocks. These system errors will cause problems when attempting to analyze radiometric variances among vegetation and land-use classes.			
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Figure 2. Technical Report Standard Title Page

TITLE: Inventory of Forest and Rangeland and Detection of Forest Stress

ERTS Proposal Number 226

Black Hills Test Site (Forest Stress) 226A

Coinvestigator: F. P. Weber

GSFC Identification Number AG-014

Principal Investigator - Robert C. Heller

STATEMENT OF PROBLEMS:

1. Although the first full year of ERTS-I operation has passed, we have yet to receive an adequate late summertime scene of the Black Hills. This coverage is required to fulfill the investigation goals of attempting to identify and classify stress from a bark beetle infestation in the ponderosa pine ecosystem. The ideal time for forest stress assessment in the Hills is late August or September. However, the only cloud-free imagery received was recorded during winter conditions. Having been unable to determine the feasibility of using ERTS data to assess forest stress, it is now important that our authorization to receive imagery be extended at least until the end of September 1973. Such an authorization will provide the opportunity to obtain imagery from three additional ERTS passes (August 15, September 2, and September 20) during the period of maximum discoloration of bark-beetle attacked trees. This is deemed especially important due to our early summer determination of the existence of a vastly larger number of beetle-killed trees in the Black Hills this year than any time in recent years.

2. There remains a problem on the processing of M-56 data flown over the Black Hills test site by the University of Michigan during May of 1972. The tapes were obtained from Michigan and sent to Purdue for digitizing. From there they were to be delivered to JSC for processing, but as yet they have not been received. The implications of this delay are serious because until the M-56 data are processed and analyzed, we cannot process the C-130 MSDS data gathered over the Black Hills test site in September 1972. Another effect is to postpone the processing of any of the ERTS MSS imagery until the results of the two aircraft MSS underflights are in hand. In retrospect, the decision not to authorize the processing of the M-56 data (collected in direct support of ERTS) at the University of Michigan (as was prior practice) has caused some very costly delays in our ERTS project which will be impossible to catch up on.

ACCOMPLISHMENTS DURING THE REPORTING PERIOD:

Equipment Developments:

1. The five RS-2M field spectrometers were moved from active data collection on the Atlanta test site to our laboratory in Berkeley. During this period the instruments were checked over for weather damage, repairs were made where necessary, and recalibrations were accomplished. The greatest problem during the first 14 months of operation was blowouts of the UDT, PiN 10DP silicon photodiode detectors. Secondly, we have had a high incidence of outage caused by problems with a Teledyne 1420 operational amplifier. We hope that remedial actions taken on these two problems will be adequate.

2. We completed cabling requirements for complete compatibility between the Atlanta and Black Hills test sites. During August when the ground truth site was reestablished in the Black Hills, duties directly connected with making the site operational required only two man-days. This compares with about two man-weeks in the past for accomplishing the same job. The task of moving from one site to another now requires the moving of nine battery packs (5 spectrometer power packs, 2 DCP power packs, and 1 multiplexer power pack), three DCP's, three DCP antennas, and all of the associated power and instrumentation data transmission cable. The four instrumentation towers at Atlanta and the five in the Black Hills are permanent fixtures which require moving only under special circumstances.

3. During the reporting period, we completed construction of two linear taper-current battery chargers which can recharge a total of 12 alkaline (13.5 volt) batteries at once. Although it would normally take 16 hours to recharge batteries which had been drained to the limit, our batteries required not more than eight hours charging. Batteries from the DCP power packs required only four hours charging. After fifty days of operation (approximately 12 hours per day), we found the spectrometer power packs to be only 60 percent discharged, while the DCP power packs, which operated 24 hours per day, were less than 20 percent discharged.

4. The construction and use of a light-activated switch on each of the spectrometer power packs has greatly increased the effective use of the power packs in the field. The principal component in the light switch is an RCA CA3062 photo diode silicon chip. The CA3062 incorporates a two-stage amplifier of sufficient output to control a heavy-duty relay. Our light switch design incorporates level adjustment for turn on and turn off at predetermined light levels. We attempt to adjust these levels so that the switch will be turned on just prior to the first early-morning ERTS pass and DCP transmission.

Aircraft Support:

1. On August 26 we flew an aerial photographic support mission with the Forest Service Aero Commander, obtaining 1:32,000 scale color infrared transparencies of the northern Black Hills mountain pine beetle infestation area. To date the photography has been processed and annotated. A commercial photographer is now making a color internegative of the original film from which our Forest Service, Region 5 photo laboratory in San Francisco, CA, will make color prints for field use. The current photography will serve several purposes: (1) as a medium for interpretation of the presence of currently faded bark-beetle killed trees, (2) as a source of data in determining the flux of the continuing bark beetle infestation in the Black Hills, (3) as supporting information for both the ERTS and Skylab data analysis programs, and (4) as a very important source of timely information for field crews on the Black Hills National Forest salvaging ponderosa pine killed by the mountain pine beetle. The latter program is proceeding at a rapid pace at this time.

Film Analysis:

Work continues using the microdensitometer to extract resource information from medium- and small-scale imagery. The current effort focuses on the best aperture configuration for retaining maximum resolution of ecosystem spots of various sizes and radiance contrasts.

WORK PLANNED FOR THE NEXT REPORTING PERIOD:

1. Final processing and analysis of ERTS DCP data collected at the Atlanta test site during June and July will be completed.

2. Analysis of DCP data collected at the Black Hills test site during August and September will be undertaken.

3. A final move of the field spectrometers will be made from the Black Hills test site to Atlanta, along with the DCP's, antennas, and associated cabling as a joint ERTS and Skylab effort.

4. We will begin the interpretation of the 1:32,000 resource photography obtained over the Black Hills during August 1973. This task being identified as an ERTS effort depends on the authorization for continuance of ERTS imagery for the Black Hills.

SIGNIFICANT RESULTS: None

PUBLICATIONS: None

RECOMMENDATIONS FOR CHANGES: A continuation of our authorization to receive ERTS imagery of the Black Hills is requested through the month of October 1973.

STANDING ORDER FORM CHANGES: None

ERTS IMAGE DESCRIPTOR FORMS: Nine

DATA REQUEST FORM CHANGES: None

TITLE: Inventory of Forest and Rangeland and Detection of Forest Stress

ERTS Proposal Number 226

Atlanta Test Site (Forest Inventory) 226B

Coinvestigator: Robert C. Aldrich

GSFC Identification Number AG-014

Principal Investigator - Robert C. Heller

STATEMENT OF PROBLEMS:

1. Retrospective orders for ERTS color composites have not been completed for key scenes to be used in our data analysis. Data not received are listed below:

<u>Scene Number</u>	<u>Date Ordered</u>
1085-15494	April 13, 1973
1174-15440	March 2, 1973
1209-15385	June 25, 1973
1265-15503	May 25, 1973
1299-15385	July 19, 1973

2. We have received no written reply to the request for a change in our Data Analysis Plan (letter to Mr. S. Provenzano dated June 19, 1973).

3. There have been no aircraft support flights since October 2, 1972, (Type II Progress Report).

ACCOMPLISHMENTS DURING THE REPORTING PERIOD:

1. A new technique is being used to combine, enhance, and enlarge bulk 70 mm ERTS images to the scale of 1:1,000,000 overlays. In this technique the I²S is used much like a photographic enlarger. Two or three 70 mm black-and-white bulk images are combined and scaled on the viewer's removable screen. Once scaled, the screen is removed and replaced by a standard 8" x 10" film holder. A timer has been ordered for the unit to allow exposures in increments of one-quarter second. A Forest Service-designed-and-built photometer will be used to evaluate the illumination levels by channel and the total illumination for all channels. When completed the unit will be used to produce combined images for all eight scenes to be used in the data analysis.

2. Film copies made from the original scribes of 1:250,000 map sheets for Atlanta, Athens, Rome, and Greenville were ordered and received from USGS. Overlays for the test site have been remade using these new base sheets. Systematic errors in point locations within the test site caused by map shrinkage have now been removed and there should be better correlation between ERTS data positions and map control.

3. We have identified and described 13 separate classes of land use on ERTS scenes 1084-15440 and 1264-15445. The descriptions have been made by Munsell notation and color names.¹ This information plus photographic examples of a selected training set will be used to train interpreters for a photo interpretation test. The test will involve 30 ERTS samples in each of eight classes (a total of 240) and will determine the feasibility of using ERTS for land-use classification as a first level of information in forest inventories.

4. A Bowens Illumitran film and slide copier has been purchased and received. This instrument is being used to produce both positive color transparencies and color negatives of selected examples of land use and forest disturbances. These examples will be used in photo interpretation training guides.

5. A preliminary photo interpretation test was completed by the coinvestigator. Ninety-two ERTS training samples (500-meter-square) that fell within the quadrangle formed by the geographic coordinates 84°00'-84°30'W longitude and 33°00'-33°30' N latitude were examined and placed in one of eight categories:

- Pine
- Hardwood
- Grassland
- Cropland
- Bare soil
- Wild vegetation
- Urban
- Water

This test was made to determine the feasibility of land classification based upon the center point rather than the NW corner of the sample square as called for in our original plan. We were also interested in knowing how fruitful land-use classification might be by interpretation of seasonal ERTS coverage.

¹The ISCC-NBS Method of Designating Colors and a Dictionary of Color Names. U. S. Department of Commerce, NBS, Circular 553. Nov. 1, 1955.

Individual scenes 1084-15440 and 1264-15445 were first interpreted one at a time. Because the sample squares are so randomly located and because specific features are so indistinguishable, it wasn't felt that any bias from learning would be present. One week following the interpretation of individual scenes, a second test was made. In this test the images in the two scenes were merged using an Old Delft scanning stereoscope with 4X magnification. This made it possible to interpret land classes based upon information from two seasons rather than one alone.

Results of the interpretation showed that only 37 of 92 points were correctly classified on scene 1084-15440 (October 15, 1972). On scene 1264-15445 (April 13, 1973) the results were even poorer; only 31 were correct. These scores are not acceptable; 80 percent would be the minimum acceptable score.

Where the two scenes were combined and interpreted together the results were much improved. In this case 59 points or 64 percent were correctly classified. These results are shown in Table 1. Although these results are far below the accuracy that is required in land-use classification, they do show enough promise to make a more complete test using improved combined color images made in our own laboratory.

6. Some progress was made on a study to monitor Forest Survey inventory plot locations using ERTS data. Aerial photographs (1:20,000 ASCS) showing plot locations and computer tabulations of both photo and ground classification have been received for five counties within the Atlanta test site. The data include the two most recent inventories--1961 and 1972. Plot transfers from 1:20,000 panchromatic photographs to 1:120,000 color infrared are proceeding using a modified Zoom Transfer Scope.

7. Work has continued during the reporting period on unsupervised clustering procedures and on procedures aimed at stratifying the data into ground types rather than spectral types. Ground truth maps have been completed for two 10,000-acre study areas and reproduced at approximately a 1:20,000 scale. These maps were prepared from 1:120,000 CIR photography taken October 2, 1972, at the same scale as computer maps produced by the EAI 430 data plotter (Type II Progress Report, July 10, 1973). The maps will be used to evaluate the final results of computer classification for ERTS scene 1084-15440 (October 15, 1972). Several computer maps based upon frequency histograms for each spectral channel have been made, and this appears to be the most successful clustering technique used to date. In this technique the frequency histogram for radiance data in each individual spectral channel is divided into a number of intervals to produce spectral clusters. We have not been able to make a final decision as to which is the best set of intervals for maximum discrimination.

Table 1. The accuracy of classification for dual-season interpretation for eight land-use classes - October 1972 and April 1973 ERTS scenes

ERTS Land Use	Ground Class						
	Pine	Hdwd	Grass- land	Crop- land	Bare Soil	Wild Veg.	Urban
	- Percent -						
Pine	<u>59</u>	9					
Hardwood	33	<u>73</u>					
Grassland		9	<u>73</u>	33		40	13
Cropland	4		27	<u>67</u>	100	20	25
Bare Soil					<u>0</u>	0	12
Wild Vegetation	4					<u>40</u>	0
Urban							<u>50</u>
Water							<u>100</u>

WORK PLANNED FOR NEXT REPORTING PERIOD:

1. We will continue preparations for a photo interpretation test based upon dual interpretation of bulk combined color data for scenes 1084-15440 and 1264-15445.
2. The transfer of Forest Survey plot locations will be completed in preparation for monitoring changes in land use and detecting forest disturbances on ERTS bulk combined color images.
3. Computer classification techniques will be used to stratify land use in two 10,000-acre study areas. The accuracy of classification will be analyzed.

SIGNIFICANT RESULTS:

ERTS bulk color composites for October 15, 1972, (scene 1084-15440) and April 13, 1973, (scene 1264-15445), when interpreted together, will disclose the location of the perennial Kudzu vine (Pueraria lobata). Kudzu, on the October scene, is a bright deep pink. On the April scene, Kudzu is a purplish gray color. Ground truth has shown that this pest is the only vegetation in the test site with this two-season spectral signature. Land managers concerned about eradicating Kudzu could use ERTS to inventory the location of all concentrations over 200 meters (660 feet) square.

PUBLICATIONS: None

RECOMMENDATIONS FOR CHANGES: None at present

STANDING ORDER FORM CHANGES: None at present

ERTS IMAGE DESCRIPTOR FORMS: A total of six submitted.

DATA REQUEST FORMS: None at present

TITLE: Inventory of Forest and Rangeland and Detection of Forest Stress

ERTS Proposal Number 226

Manitou Test Site (Rangeland Inventory) 226C

Coinvestigator: Richard S. Driscoll

GSFC Identification Number AG-014

Principal Investigator - Robert C. Heller

STATEMENT OF PROBLEMS:

1. Retrospectively ordered bulk color composites requested as early as June 19, 1973, have not yet been received. Since a significant portion of our data analysis procedures depends on these products, we need them to proceed with our plans.

2. We had some initial difficulty extracting data from the bulk-processed digital tapes of I. D. No. 1028-17135. This was due to some misinterpretation of NASA-issued program instructions. The problems have been rectified and analyses are progressing.

ACCOMPLISHMENTS DURING THE REPORTING PERIOD:

1. The system used to generate the photographic products of ERTS-I MSS data has introduced radiometric errors into the products that make it difficult to analyze the data based on recorded apparent scene radiance. This problem is not visually interpretable in the bulk-processed products except upon examination of the 15-step gray-scale tablet. Density values in the gray scale, which should be linearly related to the energy incident on the sensor, appear not to be uniform within some of the blocks.

This problem is more pronounced in the precision-processed photographic products. This was expected due to the procedure used to produce the precision imagery. It has been determined that the errors are systematic, increasing in magnitude from north to south and west to east within each reseau used to composite the precision photographic products.

To determine the radiometric fidelity of both bulk and precision photographic products, the density levels of the 15-step gray-scale tablet produced on the edge of 1:1,000,000 scale frames were measured. This was done on images of scene I. D. 1028-17135 representing MSS channels 5

and 6 using the GAF 650 microdensitometer (MDT) with an effective aperture of $1,670 \mu^2$. The resultant voltage levels of the MDT responses, linearly related to gray-scale values, were recorded by an Esterline-Angus Speed-Servo II Stripchart Recorder. The composite results of these measurements are shown in Figure 1 for the bulk-processed data and in Figure 2 for the precision-processed data. There was no significant variation in relative gray-scale values among photographic products of different MSS channels within a kind of product. However, the measured 15-step gray-scale values within a product were such to render use of apparent recorded radiometric data in the photographic products questionable. For example, in the bulk-processed data, there was a distinct step-down in gray-scale value between the more dense blocks, but these were not of the same order of magnitude. Also, at the midrange and low density levels, this step-down was not distinct and not significant between the gray-scale blocks. In addition, there was a decrease in gray-scale value between the first and fourth block of the tablet at the less dense end of the scale indicating an initial decrease in apparent radiance values before an increase in apparent radiance values, a phenomenon which should not exist.

With the precision-processed products, the apparent step-down in gray-scale values, and hence radiometric values, was more systematic than in the bulk-processed products. However, the within-block variation was equal to or exceeded between-block variation.

Estimates of the geometric accuracy of the bulk and precision photographic products of scene I. D. 1028-17135 were also determined. Errors of similar magnitude as previously reported (see Type I, No. 4 Progress Report for 3/1/73-4/30/73) were discovered.

2. Image descriptors and descriptive photo interpretation keys for the previously described forest types represented in the Manitou site have been completed for ERTS-I-support aircraft photography from Missions 205 and 211. Two of five photo interpreters have completed the photo interpretation test for these plant-community systems using the three scales of color and color infrared photographs. These data are now being analyzed to determine the accuracy of identifying these systems from the multiscale-multispectral photographs. Photo interpretation testing by the other three interpreters is now under way.

3. A more thorough classification and description of the grassland communities within the Manitou site were completed. It was necessary to delay this job until this year's vegetation had attained maximum phenological development. All photo interpretation training and testing data points for these communities have been transferred to the support aircraft photography, and image descriptors are being developed.

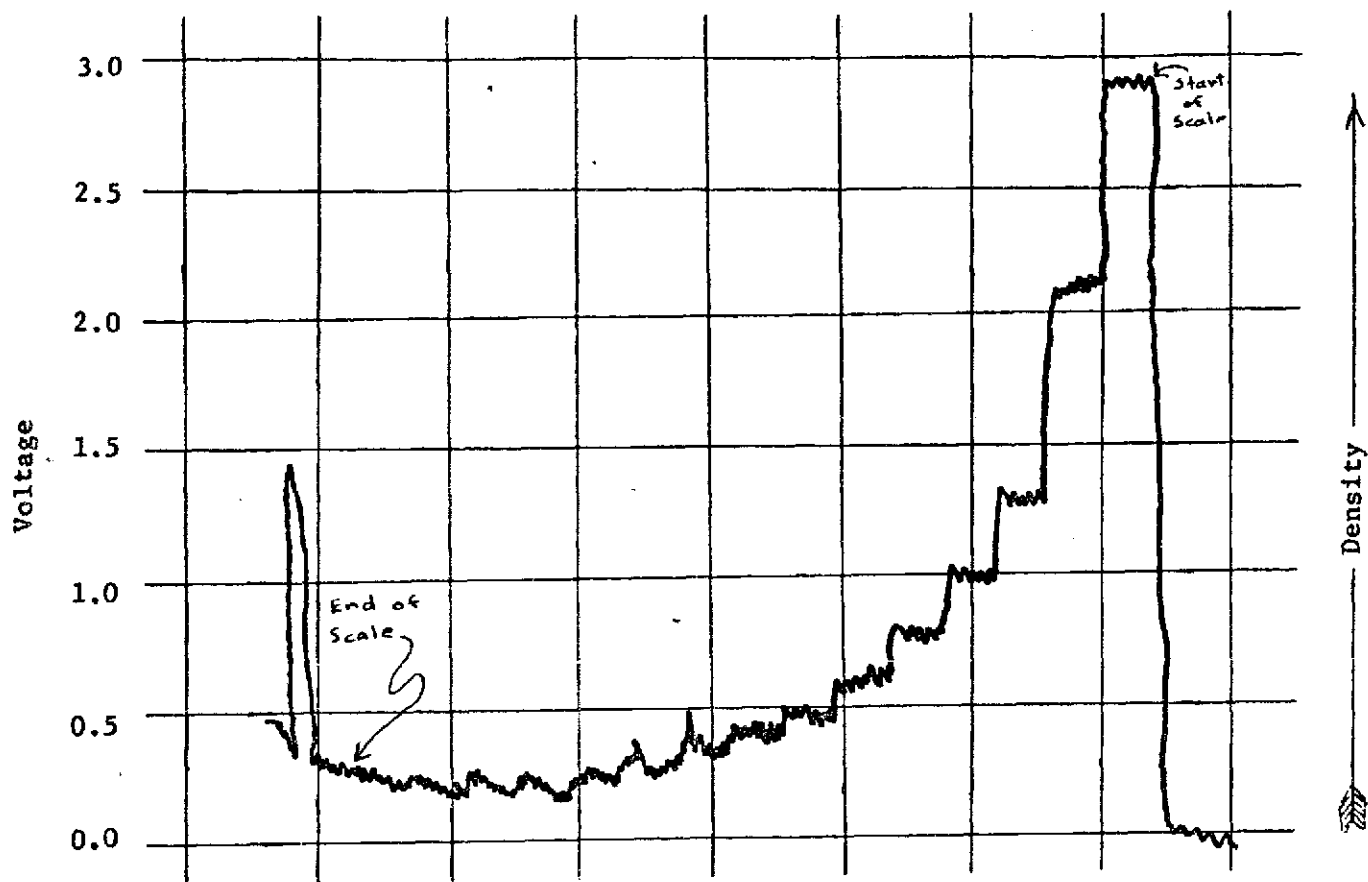


Fig. 1.--Microdensitometer trace of the 15-step gray scale tablet of bulk-processed imagery from scene I.D. 1028-17135. Each block in the gray scale gives a distinctive step in the trace for the denser end of the scale. The boundaries between blocks become indistinct as the density level decreases. However, there is an upswing in the density levels near the less dense end of the gray scale. Also, the blocks should form horizontal steps on the trace, but often are sloping, indicating a density gradient.

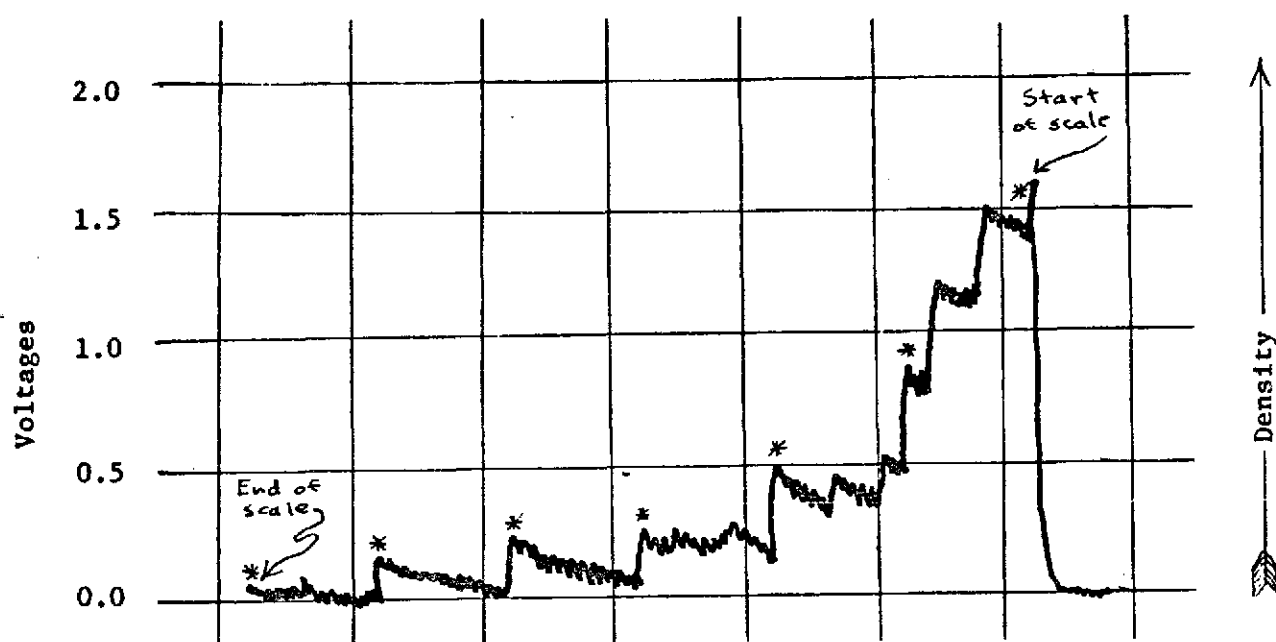


Fig. 2.--Microdensitometer trace of the 15-step gray-scale tablet of precision-processed imagery from scene I.D. 1028-17135. Each block in the denser end of the gray scale forms a distinctive step with a negative slope, but these steps are overshadowed by the more significant density changes caused by the precision processing system. The trace boundaries of these system-caused density changes are indicated by an asterisk (*). This problem renders the precision-processed data unsuitable for radiometric investigation.

4. Computer processing of the bulk CCT's of scene I. D. 1028-17135 is progressing smoothly. A gray-scale map of the Manitou site within this scene has been generated from channel 7 through computer microfilm. Five 15-mile-square subsamples within the scene have been selected for detailed analyses.

5. Field activities during this reporting period preempted continued analyses of the relationships between ground-measured radiance, standing-crop biomass, and ground cover of four different grassland classes. Work on this phase of the investigation is now being resumed.

6. Seventeen additional ERTS-I scenes of all or part of the Manitou and Kremmling sites have been received and catalogued.

WORK PLANNED FOR NEXT REPORTING PERIOD:

1. Complete photo interpretation testing for forest type classes using Mission 205 and 211 ERTS-I-support aircraft photography. Complete image descriptors of the grassland community systems and initiate photo interpretation testing.

2. Complete image descriptions of vegetation and land-use classes known to be represented within the test site included in scene I. D. 1028-17135, and initiate photo interpretation testing.

3. Resume analysis of relationships between ground-measured radiance, standing-crop biomass, and ground cover of four different grassland classes. These data will be used to determine the relationships between spectral density, spectral radiance, and ground conditions to quantify ERTS and ERAP imagery for selected plant community parameters.

4. Initiate microdensitometric point sampling for plant community and land-use classes using ERTS and ERAP imagery.

5. Investigate image enhancement of selected vegetation and land-use classes in ERTS scene I. D. 1028-17135 and supporting ERAP imagery using the I²S system in Berkeley, California. Field activities preempted these activities during this reporting period.

6. Initiate supervised and unsupervised clustering processing of the five selected areas in the bulk CCT's of scene I. D. 1028-17135.

SIGNIFICANT RESULTS:

The following significant result is identified through determinations of the radiometric fidelity of bulk- and precision-processed 1:1,000,000 scale photographic products of ERTS scene I. D. 1028-17135:

The 15-step gray-scale tablets exposed on ERTS-I bulk- and precision-processed photographic products are not of systematic equal values corresponding to $1/14$ of the maximum radiant energy incident on the MSS sensor. In the bulk products, the gray-scale block patterns near zero radiance are discrete as measured microdensitometrically. Midrange and maximum radiance values represented by the gray-scale blocks are not discrete and not significantly different among blocks. Also, the gray-scale values, which should stepwise represent specific radiance values, present a third-order polynomial function rather than a direct linear relationship.

Although the stepwise relationship in the gray-scale tablet of the precision photographic products measured microdensitometrically appear more discrete, variation within gray-scale blocks is greater than variation between gray-scale blocks. These system errors present serious problems when attempting to analyze the data, either bulk or precision products, based on apparent radiometric variances among the vegetation and land-use classes selected.

PUBLICATIONS: None

RECOMMENDATIONS FOR CHANGE: None at present.

STANDING ORDER FORM CHANGES: None at present.

ERTS IMAGE DESCRIPTOR FORMS: 10 submitted, 17 to be submitted.

DATA REQUEST FORM CHANGES: None